REMARKS

Claims 14-24 are pending and are rejected. An Information Disclosure Statement (IDS) submitted on March 29, 2006 is objected to for failing to comply with 37 CFR 1.98(a).

A telephone interview was held on October 4, 2011 (referred to herein as the "Interview") to discuss the Information Disclosure Statement and to discuss possible claim amendments that might overcome some of the reasons for rejection of the claims. The substance of the Interview is summarized in a communication from Examiner Band that was mailed on October 12, 2011 and it is also summarized below in the following remarks.

Information Disclosure Statement

The Office Action indicates an Information Disclosure Statement that was submitted on March 29, 2006 failed to comply with 37 CFR 1.98(a) because copies of three non-patent literature references were not submitted. The Office Action indicates two of the non-patent literature references (both by Toyoda) were considered but the third reference (Yamada) was not considered.

During the Interview the undersigned attorney explained that the Yamada reference was provided with IDS submitted on March 29, 2006 and on September 14, 2007. Both IDS contained a substitute form PTO-1449 and each form included a listing of the Yamada reference. An office action issued on September 17, 2009 included copies of the two substitute forms PTO-1449 that indicated the Toyoda and Yamada references had been considered.

With this explanation and clarification, Examiner Band agreed that the Toyoda and Yamada references have been submitted and that all of these references have been considered.

Claim Rejections Under 35 U.S.C. § 112

Claims 16-21 are rejected under 35 U.S.C. § 112, first and second paragraphs. The Office Action indicates the term "orthographically-projected direction" in claim 16 is not supported by the specification and is indefinite.

Four alternative amendments to claim 16 (labeled 16A to 16D) were discussed during the Interview. An agreement was reached that the rejections under § 112 could be overcome by amending claim 16 as per alternatives 16B or 16C.

The Applicants amend claim 16 as per alternative 16C and amend dependent claim 17 to conform to changes made in claim 16. Because these amendments overcome the only rejection of claim 16, they should put claim 16 and its dependent claims into condition for allowance.

Claim 23 is rejected under 35 U.S.C. § 112, first paragraph. This claim was not discussed during the Interview. The Applicants cancel claims 22-23.

Claim Rejections Under 35 U.S.C. § 103

The following prior art references are used in various combinations to support rejections of claims 14, 15, 21 and 24 under 35 U.S.C. § 103:

(A) Matsukawa et al., U.S. application publication no. 2004/0086752 ("Matsukawa")[1]

(B) Dykstra et al., U.S. patent 6,624,081 ("Dykstra")

(C) Erickson et al., U.S. patent 7,064,927 ("Erickson")

(D) Kitani et al., "Incident angle dependence of the sputtering effect of Ar-cluster-ion bombardment, 1997 ("Kitani")

(E) Hoehn et al., U.S. application publication no. 2002/0001680 ("Hoehn")

The Applicants traverse because none of the references teach what is asserted in the Office Action and no combination of this art teaches all elements of any claim.

The references and rationale stated in the Office Action have been presented in one or more previous office actions. The Applicants responded with arguments one or more times explaining why the prior art is not pertinent or is not being interpreted correctly, and why the rationale is not correct. These arguments have not been addressed. As a result, the Applicants do not have the benefit of understanding why their arguments have not been persuasive.

The Applicants request that, if the rejections of claims 14, 15, 21 and 24 are maintained, the next office action fully address their arguments and explain why they are not persuasive.

For the convenience of the Examiner, these arguments are summarized in the next several paragraphs and are presented in more detail below under the heading "Arguments Supporting Traversal of Claim Rejections." Some details provided in the previously-submitted responses are omitted here. Those details can be obtained from the responses to previous office actions if desired.

Matsukawa and Dykstra

Claims 14, 15, 21 and 24 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Matsukawa in view of Dykstra. The Office Action indicates that Matsukawa discloses all that is claimed except for varying the irradiation angle; that Dykstra teaches varying the irradiation angle; and that it would have been obvious to incorporate scanning at different angles as taught by Dykstra for scanning at a single angle as taught in Matsukawa.

[1] The Office Action cites WO 03/001614 but indicates this reference is equivalent to the Matsukawa reference and refers to Matsukawa in its discussion of the prior art. We follow the discussion in the Office Action and also refer to Matsukawa rather than the WO reference.

The Applicants disagree for each of two reasons:

(1) Matsukawa does not teach irradiating a solid surface with a gas cluster ion beam (GCIB) at irradiation angles less than 30º; and

(2) Dykstra does not teach varying the irradiation angle.

Either reason by itself is sufficient to overcome the rejection.

Matsukawa

The Office Action indicates Matsukawa "discloses surface roughness can be suppressed … with ion milling at a low angle or irradiating with a gas cluster ion beam, where the … angle of incidence of the ion beam at the surface is 5º to 25º and is capable of having an angle of incidence between 0º and 90º" (citing paragraphs [0005] and [0034]).

As stated in their response to a previous office action, the Applicants do not understand how paragraph [0005] is relevant to irradiation angles. If this text is still believed to be relevant, they request some explanation why it is believed to be relevant.

Regarding paragraph [0034], the Applicants submit that the Office Action relies on an interpretation that would not be adopted by a person of ordinary skill in the art. The Applicants' arguments that support this conclusion may be found in responses to previous office actions and in the "Arguments Supporting Traversal of Claim Rejections" provided below. Those arguments are incorporated here by reference so that this portion of the response can be presented more concisely.

As explained in those arguments, a person of ordinary skill in the art would understand that paragraph [0034] does not teach or even suggest that a solid surface can be smoothed by irradiating that surface with a GCIB at a radiation angle less than 30º as measured from the surface.

If it is still believed that Matsuakwa teaches what is asserted in the Office Action, the Applicants request that the next office action fully address the arguments presented below under the heading "Overview and Background of Matsukawa."

Dykstra

The Office Action refers to scanning angles disclosed in Dykstra and indicates these angles are somehow related to the irradiation angle recited in the claims.

The Applicants disagree and submit that the scanning angle and the irradiation angle are not the same angle. The teachings in Dykstra that pertain to scanning angles are irrelevant to the irradiation angle. The Applicants' arguments that support this conclusion may be found in the response to the previous office actions and in the "Arguments Supporting Traversal of Claim

Rejections" provided below. Those arguments are incorporated here by reference so that this portion of the response can be presented more concisely.

If it is still believed that Dykstra teaches varying an irradiation angle, the Applicants request that the next office action fully address the arguments presented below under the heading "Overview of Dykstra."

Matsukawa and Erickson

Claims 14, 15, 21 and 24 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Matsukawa in view of Erickson. The Office Action indicates that Matsukawa discloses all that is claimed except for varying the irradiation angle; that Erickson teaches sweeping the trajectories of GCIB at different angles; and that it would have been obvious to incorporate sweeping GCIB at different angles as taught by Erickson for the single trajectory as taught in Matsukawa.

The Applicants disagree for each of two reasons:

(1) Matsukawa does not teach irradiating a solid surface with a gas cluster ion beam (GCIB) at irradiation angles less than 30º; and
(2) Erickson does not teach varying the irradiation angle between the GCIB and the solid surface to be smoothed.

Either reason by itself is sufficient to overcome the rejection.

Matsukawa

The reasons for traversal of Matsukawa are summarized above and discussed below. If it is still believed that Matsuakwa teaches what is asserted in the Office Action, the Applicants request that the next office action fully address the arguments presented below under the heading "Overview and Background of Matsukawa."

Erickson

The Office Action refers to different ion beam trajectories disclosed in Dykstra and indicates these trajectories are somehow related to the irradiation angle recited in the claims.

The Applicants disagree and submit that, although Erickson discloses different trajectories, these different trajectories irradiate a solid surface at the same irradiation angle. Erickson does not disclose changing the irradiation angle. The Applicants' arguments that support this conclusion may be found in the response to the previous office actions and in the "Arguments Supporting Traversal of Claim Rejections" provided below. Those arguments are incorporated here by reference so that this portion of the response can be presented more concisely.

If it is still believed that Erickson teaches varying an irradiation angle, the Applicants request that the next office action fully address the arguments presented below under the heading "Overview of Erickson."

Kitani and Dykstra

Claims 14, 15, 21 and 24 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Kitani in view of Dykstra. The Office Action indicates that Kitani discloses all that is claimed except for varying the irradiation angle; that Dykstra teaches varying the irradiation angle; and that it would have been obvious to incorporate scanning at different angles as taught by Dykstra for scanning at a single angle as taught in Kitani.

The Applicants disagree for each of two reasons:

(1) Kitani does not teach irradiating a solid surface with a gas cluster ion beam (GCIB) at irradiation angles less than 30º; and

(2) Dykstra does not teach varying the irradiation angle.

Either reason by itself is sufficient to overcome the rejection.

Kitani

The Office Action indicates Kitani "discloses that larger angles than 45º can be used since the desired smoothing effect is dependent on the incident angle" and that "the determination of the optimum or workable ranges of [the incident angle] might be characterized as routine experimentation."

The Applicants respectfully traverse and submit that the Office Action has not shown that Kitani either discloses or renders obvious the claimed irradiation angle. The Applicants' arguments that support this conclusion may be found in responses to previous office actions and in the "Arguments Supporting Traversal of Claim Rejections" provided below. Those arguments are incorporated here by reference so that this portion of the response can be presented more concisely.

If it is still believed that Kitani teaches what is asserted in the Office Action, the Applicants request that the next office action fully address the arguments presented below under the heading "Overview of Kitani."

Dykstra

The reasons for traversal of Dykstra are summarized above and discussed below. If it is still believed that Dykstra teaches varying an irradiation angle, the Applicants request that the next office action fully address the arguments presented below under the heading "Overview of Dykstra."

Kitani and Erickson

Claims 14, 15, 21 and 24 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Kitani in view of Erickson. The Office Action indicates that Kitani discloses all that is claimed except for varying the irradiation angle; that Erickson teaches sweeping the trajectories of GCIB at different angles; and that it would have been obvious to incorporate sweeping GCIB at different angles as taught by Erickson for the single trajectory as taught in Kitani.

The Applicants disagree for each of two reasons:

(1) Kitani does not teach irradiating a solid surface with a gas cluster ion beam (GCIB) at irradiation angles less than 30º; and

(2) Erickson does not teach varying the irradiation angle between the GCIB and the solid surface to be smoothed.

Either reason by itself is sufficient to overcome the rejection.

The reasons for traversal of Kitani and Erickson are summarized above and discussed below. If it is still believed that Kitani and Erickson teach what is asserted in the Office Action, the Applicants request that the next office action fully address the arguments presented below under the headings "Overview of Kitani" and "Overview of Erickson."

Hoehn and Dykstra

Claims 14, 15 and 21 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Hoehn in view of Dykstra. The Office Action indicates that Hoehn either discloses or implies all that is claimed except for varying the irradiation angle; that Dykstra teaches varying the radiation angle; and that it would have been obvious to incorporate scanning at different angles as taught by Dykstra for scanning at a single angle as taught in Hoehn.

The Applicants disagree for each of two reasons:

(1) Hoehn does not teach any technique for smoothing a surface; and

(2) Dykstra does not teach varying the irradiation angle.

Either reason by itself is sufficient to overcome the rejection.

Hoehn

The Office Action indicates Hoehn discloses "a beam generator operating at an angle formed between a solid surface and said ion beam generator being between 25º and 75º, where said beam generator is a gas cluster ion beam" and it concludes that "it is either inherent or obvious that Hoehn et al. discloses using a gas cluster ion beam at an angle formed between the solid surface and the ion beam generator less than 30º."

Whether these statements are true or not, the Office Action has not shown that Hoehn discloses anything about smoothing a surface. The Applicants are unable to find anything in Hoehn that discloses smoothing, flattening, reducing roughness or some other equivalent concept. Instead, Hoehn discloses several techniques to reduce the thickness of a coating formed on a substrate (see Abstract and paragraphs [0007] to [0009]). The disclosed techniques rely on special properties of fullerene molecules to reduce the thickness of a fullerene coating to essentially one molecule (see Abstract and paragraphs [0009] to [0010]).

Hoehn does not indicate whether the disclosed techniques will increase, decrease or leave unchanged the original smoothness of a fullerene coating. It should be clear, however, that the disclosed techniques do not affect the smoothness of the underlying substrate surface and the disclosed techniques cannot ensure that the resulting smoothness of the surface is greater. Instead, it seems likely the disclosed techniques will either preserve or increase surface roughness.

Arguments supporting this conclusion may be found in the response to the previous office action and are also presented below in the "Arguments Supporting Traversal of Claim Rejections." The arguments presented below are incorporated here by reference so that this portion of the response can be presented more concisely.

If it is still believed that Hoehn teaches what is asserted in the Office Action, the Applicants request that the next office action fully address the arguments presented below under the heading "Overview of Hoehn."

Dykstra

The reasons for traversal of Dykstra are summarized above and discussed below. If it is still believed that Dykstra teaches varying an irradiation angle, the Applicants request that the next office action fully address the arguments presented below under the heading "Overview of Dykstra."

Hoehn and Erickson

Claims 14, 15 and 21 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Kitani in view of Erickson. The Office Action indicates that Hoehn either discloses or implies all that is claimed except for varying the irradiation angle; that Erickson teaches sweeping the trajectories of GCIB at different angles; and that it would have been obvious to incorporate sweeping GCIB at different angles as taught by Erickson for the single trajectory as taught in Hoehn.

The Applicants disagree for each of two reasons:

(1) Hoehn does not teach any technique for smoothing a surface; and

(2) Erickson does not teach varying the irradiation angle between the GCIB and the solid surface to be smoothed.

Either reason by itself is sufficient to overcome the rejection.

The reasons for traversal of Hoehn and Erickson are summarized above and discussed below. If it is still believed that Hoehn and Erickson teach what is asserted in the Office Action, the Applicants request that the next office action fully address the arguments presented below under the headings "Overview of Hoehn" and "Overview of Erickson."

Arguments Supporting Traversal of Claim Rejections

Overview and Background of Matsukawa

Overview

As an initial observation, Matsukawa does not state or even suggest that it is disclosing anything new in the use of ion beams to smooth a surface. The principal teachings in Matsukawa pertain to a magnetoresistive element that has improved magnetoresistance characteristics. Matsukawa discloses the use of an ion beam as merely a conventional step to smooth a surface.

The Office Action relies on paragraph [0034] to assert Matsukawa discloses the use of a GCIB at low radiation angles. Paragraph [0034] in Matsukawa reads as follows:

> The surface roughness of the underlying film can be suppressed by ion-milling the surface at a low angle or irradiating it with a gas cluster ion beam. The ion beam irradiation may be performed so that the angle of incidence of the ion beam at the surface of the underlying film is 5° to 25°. Here, the angle of incidence is 90° when the ion beam orients perpendicular to the surface and is 0° when it orients parallel to the surface.

The first sentence in this paragraph refers to two different types of ion beam radiation. The first type is "ion milling" that irradiates a material with a beam of individual atomic or molecular ("monomer") ions. The second type uses a beam of clusters of atomic or molecular ions. This sentence states that monomer ion beams may be used at a low radiation angle but does not indicate anything about what radiation angle should be used for a gas cluster ion beam.

It was known in the prior art that these two types of ion beam radiation have very different characteristics. For example, see the last paragraph on page 256 of Yamada et al., "Materials processing by gas cluster ion beams," Materials Science and Engineering R34 (2001), pp. 231-295. A person of ordinary skill in the art knew that statements about the radiation angles for a monomer ion beam did not apply to the radiation angles of a cluster ion beam.

The second sentence in paragraph [0034] states the following:

> "The ion beam irradiation may be performed so that the angle of incidence of the ion beam at the surface of the underlying film is 5° to 25°."

This second sentence is either ambiguous or can be misleading if it is interpreted within only the context of paragraph [0034] alone. There are three possible interpretations:

(1) the term "ion beam" refers to both monomer and cluster ion beams;
(2) the term "ion beam" refers only to a cluster ion beam; or
(3) the term "ion beam" refers only to a monomer ion beam.

The Applicants respectfully submit that a person of ordinary skill in the art would understand that this second sentence refers only to monomer ion beams. This conclusion is supported by the full context of the Matsukawa disclosure as well as what was known and understood in the art at the time the Matsukawa reference was filed (October 2003).

Background

The material in Yamada et al. represents what was known in the art about the effects of incidence angle on smoothing by monomer and cluster ion beams. The Applicants are not aware of any art that teaches a contrary view.

It was and is still well known that the smoothing effect of monomer ion beams is very poor for normal radiation angles but improves as the angle departs from normal. For example, see Yamada et al. mentioned above, and Panin et al., "p- to n-type Conversion in GaSb by Ion Beam Milling," Appl. Phys. Letters, vol. 67, no. 24, Dec 1995, pp.3584-3586. (These two references as well as all other references cited herein as well as in the arguments presented in responses to previous office actions have been disclosed in IDS.)

The smoothing properties of monomer ion beams and GCIB are different. According to Yamada et al. and all other known art, the smoothing effect achieved by GCIB is maximum for normal incidence and progressively degrades as the radiation angle departs from normal. See section 4.1.2 on pages 256-259 and section 4.3 on pages 266-273. (Yamada refers to an incidence angle that is complementary to the angle defined in Matsukawa.; therefore, Yamada et al. indicates the smoothing effect of GCIB degrades as the radiation angle defined in Matsukawa decreases to thirty degrees.)

Fig. 47 on page 270 of Yamada is reproduced below. It illustrates the effect that the incidence angle has upon the smoothing effect of GCIB. Similar effects are illustrated in other figures and discussed throughout the Yamada reference.

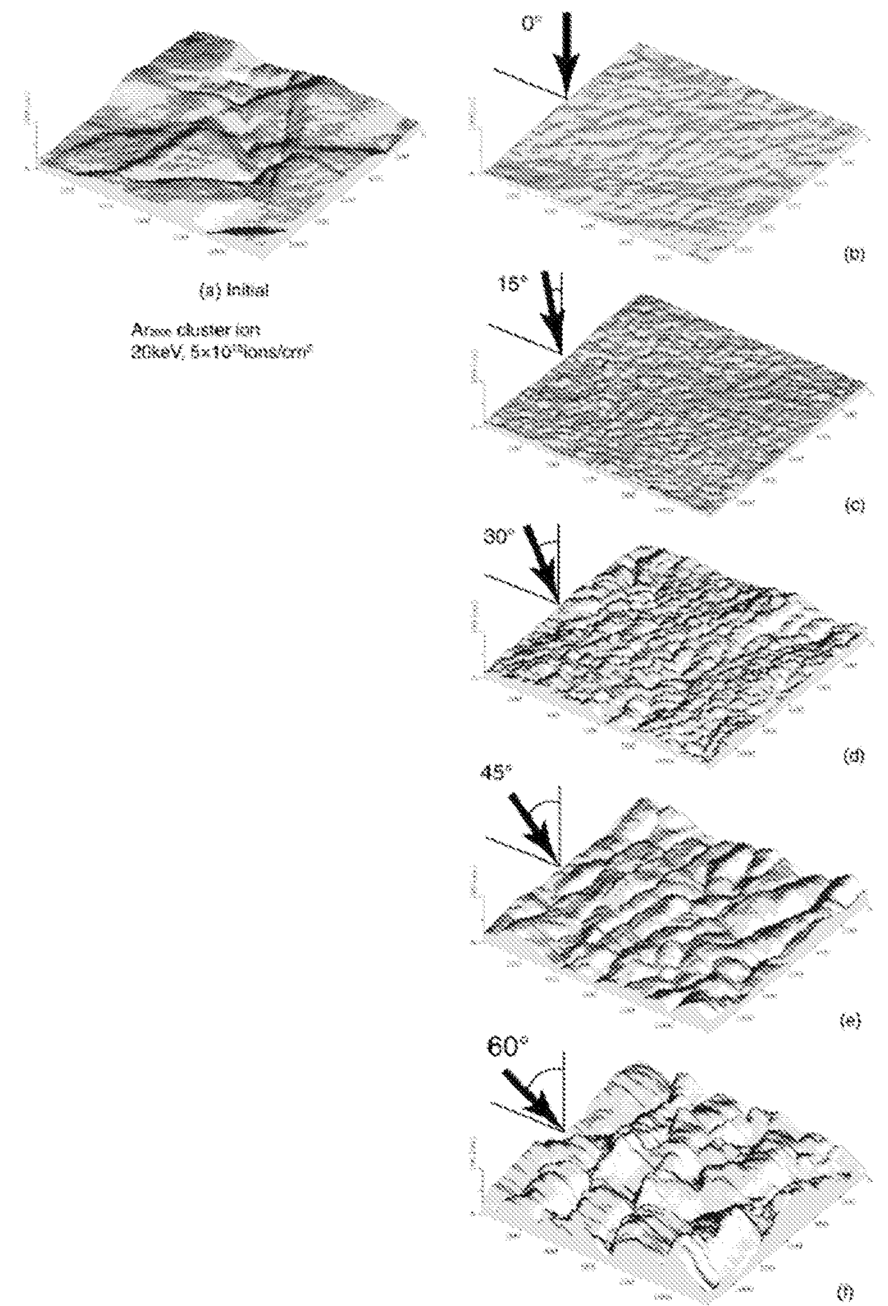


Fig. 47. AFM images of Cu surface irradiated with Ar cluster ions at various incident angles from 0 to 60°.

Yamada et al. and all other known prior art taught using GCIB only at normal or near normal irradiation angles to smooth surfaces. Yamada et al. does not discuss the smoothing effect of GCIB at irradiation angles smaller than 30°. The Applicants believe the authors of Yamada et al. concluded that using even smaller angles would yield even worse results and chose not to study these smaller angles. <u>This opinion is also supported by the Kitani reference discussed below.</u>

Conclusion

Referring again to the observation that Matsukawa does not state or even suggest that it is disclosing anything new in the use of ion beams to smooth a surface, it would be a very remarkable thing indeed if Matsukawa had intended to disclose something contrary to the prior art without at least some explanation, clarification or justification. There is nothing of the kind.

The Applicants conclude that the second sentence in paragraph [0034] was not intended to refer to GCIB and they respectfully submit that the person of ordinary skill in the art would have understood this second sentence refers only to monomer ion beams or so-called ion milling. The Applicants respectfully submit that a person of ordinary skill in the art would have understood paragraph [0034] in Matsukawa to disclose only conventional ion beam smoothing, which is either by a monomer ion beam at a small incidence angle or by a cluster ion beam at a conventional angle, which is normal or near normal incidence.

This conclusion is consistent with the remaining disclosure in Matsukawa. For example, paragraph [0072] describes small radiation angles for only a monomer ion beam. Matsukawa does not disclose any example or embodiment that uses GCIB at so-called low angles.

All known prior art is consistent with this conclusion.

<u>Overview of Dykstra</u>

Dykstra discloses an apparatus in which a GCIB is deflected by some angle or “offset” onto a substrate to be etched. Unwanted ionizing radiation is allowed to propagate along the original undeflected path. This arrangement eliminates harmful ionization on the surface of the substrate.

Referring to page 5, the Office Action characterizes Dykstra as teaching a “GCIB initially directed along a preselected axis where said GCIB is directed offset from the preselected axis” and that “while an example of the offset angle is 15° from the preselected axis (i.e. GCIB hits the substrate at an angle of 75°), other larger angles than 15° may be used.”

The Applicants respectfully submit that the angles referred to in the Office Action do not pertain to the angle of incidence with respect to the surface of a substrate that is irradiated by the GCIB. The Applicants are unable to find anything in the text of Dykstra that discloses any incidence angle as measured with respect to the substrate surface.

The Office Action indicates that the 15° degree angle disclosed in Dykstra represents a GCIB that “hits the substrate at an angle of 75°.” The Applicants respectfully submit that this is not correct. Dykstra states the substrate to be etched is “positioned in line with the offset gas cluster ion

beam." (see col. 3 lns. 52-53). In view of what was known in the art, this statement does not suggest any angle of incidence relative to the surface that is other than conventional normal incidence.

The Office Action further indicates that Dykstra discloses using different angles. What is actually disclosed differs from what is claimed in at least two respects: (1) the angle disclosed in Dykstra does not refer to an angle of incidence as explained above, and (2) the use of different angles refers to *a priori* choices that remain fixed or unchanging during GCIB irradiation. The only variation is that which is needed to scan the beam in a raster pattern as is done in other GCIB apparatuses. This tiny variation is referred to as the "scan angle" in Dykstra and is used in conventional apparatuses to direct a GCIB in a raster pattern onto a surface with essentially normal incidence. In contrast to what is disclosed, the claimed methods changes the angle of incidence to vary on either side of 30º from the surface.

<u>Overview of Erickson</u>

Erickson discloses a conventional apparatus in which a GCIB is directed onto a substrate. The beam is deflected electrostatically in a raster pattern.

The Office Action states the following:

> "Fig. 4 depicts the gas cluster ion beam [64] impacting the semiconductor substrate [52] by sweeping at different trajectories that can be repeated. Fig. 4 also depicts that the gas cluster ion beam [64] is projected at an initial incident angle of 0º, where the trajectories of said gas cluster ion beam [64] appear to be swept at a different angle less than 90º."

As an initial matter, the Office Action seems to refer to the same angle in different terms, sometimes referring to it as 0º and sometimes referring to it as 90º. The Applicants believe this discrepancy is due to a simple typing mistake but it is important to point out this discrepancy to clarify that there is only one incident angle that is disclosed in Erickson, namely, one that is normal to the surface.

The GCIB apparatus illustrated in Fig. 4 and described in Erickson is a conventional GCIB apparatus. It is well known that this apparatus emits GCIB and irradiates surfaces at normal angles or angles very close to normal. The "trajectories" mentioned in the Office Action are merely small deflections needed to scan the beam in a raster pattern. This is clearly stated in the text that is cited in the Office Action.

The Office Action refers to an "<u>initial</u> angle" (emphasis added) but there is no other angle disclosed or suggested in Erickson. The Office Action indicates that the "trajectories of said gas cluster ion beam appear to be swept at a different angle less than 90º"without explaining what in Erickson is believed to make this apparent. The Applicants can only guess this assertion is based on

what is illustrated in Fig. 4. In the figure, a GCIB is shown to impinge on a surface at an angle that is not normal. If this is the basis for the assertion, then the Applicants strongly disagree and submit that the figure is merely a schematic illustration of known apparatuses that irradiated surfaces with GCIB at normal angels. While the electrostatic deflections mentioned in Erickson do change the angle of incidence, these changes are very small and result in an angle of incidence that is essentially equal to normal at all times. The person of ordinary skill in the art would not understand Erickson to disclose irradiation angles that depart significantly from normal.

Referring to page 7, the Office Action indicates it would have been obvious to replace the "single trajectory of Matsukawa" with the "different trajectories" in Erickson. This mischaracterizes the art. As explained above. The "trajectories" mentioned in Erickson are merely the orthogonal deflections needed to effect a raster scan of the GCIB. The GCIB apparatus that is referred to in Matsukawa and in the other references is the same type of apparatus. Erickson does not add any relevant teaching to what is disclosed in Matsukawa and the other primary references.

Finally, even if Erickson or Dykstra did disclose significant variations in incident angle, it would be incorrect and unsupported by the art to conclude that such a teaching would render obvious the use of irradiation angles that the prior art taught would result in increased roughness.

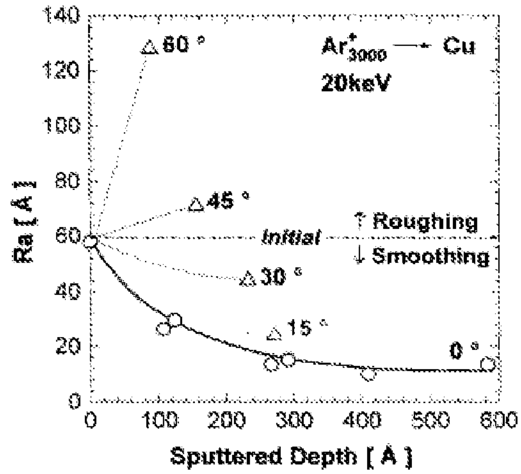
<u>Overview of Kitani</u>

Kitani discloses the use of radiation angles that range from zero degrees to sixty degrees from normal but does not disclose the use of any angle greater than sixty degrees from normal. The Office Action states that "Kitani also discloses that larger angles than 45° <u>can</u> be used since the desired smoothing effect is dependent on the incident angle, thus the angle used for the smoothing effect is a result-effective variable" (emphasis added).

The Applicants respectfully traverse this line of argument for two reasons. First, Kitani does not disclose that angles greater than 60° can be used, which is the angle that is pertinent to what is claimed. Second, whether something <u>can</u> be used is not the proper inquiry for patentability. Instead, a proper inquiry should determine what would have been obvious to a person of ordinary skill in the art. The Applicants refer to their previous arguments for supporting details and respectfully submit that Kitani teaches away from what is claimed. Referring to the last paragraph of section 3 on p. 491, Kitani states the following:

> "… For larger incident angles than 45°, the <u>roughness increased</u> with the amount of irradiation. It is clear that the smoothing effect of cluster ion bombardment is strongly dependent on the incident angle." (emphasis added)

Fig. 3 on page 491 in Kitani also shows that the initial roughness of a surface increases for incident angles equal to or greater than forty-five degrees, and increases dramatically for angles greater than sixty degrees, which is the range of angles that is claimed.



The Office Action further states that it has been "held that a particular parameter must first be recognized as a result-effective variable … before the determination of the optimum or workable ranges of said variable might be characterized as routine experimentation" (citing MPEP 244.05, Section II, Part B).

The Applicants respectfully submit that the Office Action refers to a section of the MPEP that is not applicable to the present situation and it misapplies the law stated therein. The text in the MPEP that is referred to pertains to work that is deemed to be routine experimentation because it optimizes something <u>within</u> prior art conditions. As noted above, the claimed range of angles lies outside of the range that is disclosed in Kitani. Instead, the claimed angles are in an untried, untested range that empirical evidence indicated will not work. The use of a radiation angle larger than 60º as measured in Kitani is not within the realm of routine experimentation.

Kitani and other prior art teach away from what is claimed. According to Kitani, if the radiation angle is greater than 45° as measured from the normal, <u>roughness increases</u>. This is the opposite of smoothing. Kitani indicates this roughening effect increases more rapidly with further increases in angle. If the skilled person wanted to smooth something, there would be no obvious reason to try angles larger than 45°. Kitani et al. tried some of these larger angles and reported very clearly that roughness increases. There is no suggestion in Katani that angles greater than 60º can or should be used to smooth a surface.

Overview of Hoehn

Hoehn discloses several techniques using monomer ion beams, GCIB, laser beams and solvents to process a fullerene coating formed on the surface of a substrate (see Abstract). These techniques rely on special properties of fullerene molecules to remove all of a fullerene coating except a single molecular layer on the substrate surface.

The techniques in Hoehn require that the bond between fullerene molecules in the coating and molecules in the substrate (fullerene-to-substrate) be stronger than the bond between fullerene molecules within the coating (fullerene-to-fullerene). Various processes such as ion beams, laser beams and solvents are disclosed that can break the fullerene-to-fullerene bonds but not break the fullerene-to-substrate bonds. As a result, these processes can remove the upper molecular layers of a multi-molecular layer fullerene coating and leave a coating that has "approximately one layer of fullerene molecules" on the substrate (see paragraph [0029]).

The text in paragraph [0029] also indicates that the thickness of the resultant coating is not exactly one molecule thick:

> … establishing the presence of an absolute single layer [of molecules] is problematic. Consequently, as used herein, the term "monolayer" as applied to a coating of fullerene means a coating approximately one layer of fullerene molecules, although the properties of the coating are not significantly affected if the coating is slightly more or less than a monolayer.

A coating that is "slightly … less" than a monolayer means no coating is present. Hoehn does not explain what constitutes being "slightly more" than a monolayer but this must include at least two molecular layers. As a result, Hoehn indicates that the disclosed techniques cannot ensure a uniformity of thickness that is less than the thickness of at least two fullerene molecular layers.

Hoehn does not indicate whether the disclosed techniques will increase, decrease or leave unchanged the original smoothness of the fullerene coating. What is clear, however, is that the disclosed techniques do not affect the smoothness of the underlying substrate surface. As a result, it may be seen that the overall roughness of the surface of the fullerene coating will depend on the roughness of the substrate plus the additional variation of thickness in the fullerene coating, which statistically will always be rougher than the initial roughness of the substrate surface.

Hoehn does not teach any technique with a GCIB that can be used to ensure the surface of a solid can be made smoother. Instead, the disclosed techniques seem likely either to preserve or to increase surface roughness. As a result, Hoehn does not disclose anything that a person skilled in the art would understand is a method for smoothing the surface of a solid.

CONCLUSION

Applicants cancel claims 22-23, amend claims 16-17, which they believe puts claim 16 and its dependent claims into condition for allowance, and they request reconsideration of the remaining claims in view of the discussion set forth above.

Respectfully submitted,

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Certificate of Transmission

I certify that this Response to Office Action and any following materials are being transmitted electronically on January 13, 2012 to the U.S. Patent and Trademark Office (USPTO) via the USPTO electronic filing system (EFS-Web).

David N. Lathrop